

Respiratory Protection of Healthcare Workers in Future Pandemics

1) Background

Anyone who watched the recent ITV drama, [Breathtaking](#) will have seen the central character, Dr Abbey Henderson, failing a 'face fit test' when using a FFP3 respirator during the Covid pandemic.

The explanation by the person carrying out the test was "...**these FFP3s are made for wider jaws**" and Dr Henderson's comment in return "...**life-saving for men!!**". She recognised that with a respirator which didn't fit tightly to her face she was endangered by the virus being able to enter the respirator and infect her. Despite this she bravely continued her work.

The reality is that this short clip in a TV drama, repeated hundreds of times over in real life, exposed a major failing in the provision of this type of Respiratory Protective Equipment (RPE) for healthcare workers (HCW) during the pandemic – it requires a good tight fit to the face in order to avoid leakage.

2) The issue

FFP3 (Filtering Face Piece) respirators provide an excellent level of respiratory protection and are recommended by HSE as providing a suitable level of protection against airborne microbiological risks in their official [guidance](#)¹ (appendix 6). **HSE does not recommend surgical masks (of any type) for this purpose.** It makes no difference whether a particular pathogen is "wholly airborne" or "predominantly airborne", which seems to have preoccupied the minds of IPC policy makers. If a pathogen is airborne to any extent, then RPE is needed to protect healthcare workers, particularly when providing close quarter care to infectious patients for long periods of time, as is the case during a pandemic. The fact that there may be other routes of transmission such as 'contact' or 'droplet' does not mean the 'airborne/aerosol' route can be ignored. Such a premise would be entirely illogical and, in any event, contrary to health and safety legislation.

The material from which FFP3 respirators are made provides an efficient physical filter for very small particles and aerosols. In addition, the application of an electrostatic charge during the manufacturing process significantly enhances their ability to trap these airborne contaminants. As such, FFP3 respirators are a far cry from fluid resistant surgical masks which do not protect the wearer against inhalation of airborne contaminants but merely give the wearer a false sense of security which, in its own right, is a danger. HSE scientists conclusively demonstrated the unsuitability of FRSMs for use in a pandemic as long ago as 2008, with live viruses being detected behind every type of mask they tested.

FFP3 respirators are widely used in other working environments such as the manufacturing, chemical and engineering sectors. However, in line with HSE's guidance, they are typically used to protect workers undertaking activities which involve relatively short periods of time.

FFP3s have a valuable place in the healthcare sector for relatively short, ad-hoc exposures to infectious patients, but are inappropriate for staff who have to spend much of their time in close contact with suspected or confirmed infectious patients, day after day, such as during a pandemic as they become very uncomfortable. HSE guidance states "*it is recommended that continuous wear time for tight-fitting (unpowered) RPE is less than an hour*" and "*where RPE is required to be worn continuously for long periods, powered respirators...with a loose-fitting facepiece such as a hood or helmet are better options*".

During the Covid-19 pandemic, from April 2020, it became custom and practice for FFP3s to be used for 'sessional use' which IPC guidance defined as up to 6 hours at a time. This caused wearers to experience adverse effects such as skin rashes.

FFP3s were the only type of respirator stockpiled in the pandemic emergency stores and were the only type available during the height of the pandemic. Consequently, as highlighted during the Covid Inquiry, much of the campaigning from professional bodies and unions was for these to be more available to staff beyond the restriction of their use to certain procedures and situations.

A step change in mindset is required amongst emergency planners. There needs to be far greater recognition of the valuable role that powered respirators have to play in pandemics, epidemics and even their potential use in local outbreaks of serious diseases.

I suspect that many front-line HCWs who were lucky enough to be provided with life-saving FFP3 respirators would agree that they are far from ideal when it comes to prolonged close-quarter care of patients and would welcome a more comfortable device which provides equivalent or better protection.

¹ [HSG53](#) 'Respiratory Protective Equipment at Work'

3) Equality issues / Conformity with safety standards

FFP3 respirators must be tested and certified to conform to the standard BS EN 149:2001. This requires the FFP3 to be mounted on a 'Sheffield Dummy Head' so that various measurements can be taken. This represents the facial features of a **white male**. The same dummy head is also used for BS EN 140:1999 which is the standard for a reusable type of tight-fitting RPE such as elastomeric half-masks. The use of this device for testing and certifying RPE dates back over 30 years.



Fig 1: The 'Sheffield Dummy Head'

Source: [Science Purge Technology](#)

It is illegal for suppliers to sell RPE in the UK which does not conform to these standards or is otherwise approved by the Health and Safety Executive.

No provision was made during the pandemic planning process to cater for the respiratory protection needs of other ethnic groups or females who have different facial characteristics (morphology). In a diverse working community such as the NHS this was a major omission.

There was also a failure to consider men of certain faiths who are required to have beards and other faiths where they choose to do so as a symbol of religious piety or devotion. Tight-fitting masks simply do not provide an effective seal to the face when the wearer has facial hair. Similarly, the practical issues arising from the wearing of religious attire such as turbans and hijabs were not considered.

In future pandemic planning we must keep the provisions of the Equality Act 2010 firmly in mind, since omission to provide effective RPE protection for **all** workers regardless of gender, faith or ethnicity would contravene this legislation.

4) Healthcare Worker Response to a Future Pandemic – Willingness to serve?

In November 2023 I attended a meeting of the 'Safer Healthcare Biosafety Network' at which an excellent talk was given by NHS Resolution who presented their '[Being Fair 2](#)' initiative. This addressed issues relating to 'workplace culture', the way that some staff in the NHS are treated (incivility, endemic bullying etc) and how this might be overcome.

In the Q&A I commented that during my work over the previous 3 years I had come across many NHS staff who had been severely harmed by the disease, were suffering from post-COVID syndrome so badly that they can no longer work, without support packages and facing financial and emotional ruin.

This gives rise to the question as to whether, having witnessed the impact of the Covid-19 pandemic on colleagues in terms of disease and death and the way survivors have been treated, this may have irreversibly compromised their trust in the organisation's ability to keep them safe when confronted with any future pandemic. The concern being as to whether this might give rise to a widespread 'refusal to treat' in the event of a future pandemic – with all the mayhem and civil disorder that would most likely ensue if the health service collapsed.

The response from our colleague in NHS Resolution was that the majority of HCWs are incredibly dedicated and will go "above and beyond". Indeed that is absolutely true and this has been manifestly evident during the darkest days of the pandemic. We all salute them all for their selfless dedication.

However, my contention is that HCWs should not be forced into a position where "going above and beyond" presents a very real danger to their life and to that of their families at home. To prepare for a future pandemic with this expectation in mind would represent a serious breach of Article 2 of the EU Charter of Fundamental Rights (i.e. 'Right to Life').

It is reasonably foreseeable that, in the event of a future pandemic, basic human instincts of self-preservation will hold sway. If staff again walk onto a ward only to again be told “these surgical masks will keep you safe” and “we have to follow national guidance”, many will turn round and walk straight back out again. The greater the Case Fatality Ratio (CFR) of an emerging pandemic, the more likely this is to happen. With COVID-19 the CFR was relatively low (an estimated 2.5 to 3% at the outset), whereas with other foreseeable pandemics such as SARS(1), MERS and Avian Flu H5N1 (where limited human-to-human transmission has already occurred) the CFR would be 5 to 10 times higher, if not more.

However, rebuilding HCW trust is neither impossible nor insurmountable. They need to see a genuine acceptance that where mistakes were made they will never be made again. More importantly HCWs, and their elected safety representatives in Trade Unions, need to see actual positive action and investment in the provision of better control of airborne risk. This should include improvements in ventilation and air-purification in places where contact with infectious patients is anticipated. However, there also needs to be a recognition that this alone will not keep workers safe when delivering close contact care. As one of the attendees at the meeting astutely observed during the Q&A, Respiratory Protective Equipment will always be needed as a part of ‘airborne precautions’ to protect against the close-range aerosol plume emanating from infectious patients.

5) Powered Air Purifying Respirators (PAPRs)

As discussed above, there are many reasons why FFP3 respirators should not be the RPE of choice for sessional use during pandemics.

An example of an NHS Trust which recognised the airborne nature of COVID-19 early in the pandemic and managed HCW protection in a proactive and responsible manner was University Hospital Southampton. Facing the acute shortage of RPE they, together with the university, developed a powered respirator which they named the PeRSO (**P**ersonal **R**espirator **S**outhampton). The development work was carried out at pace, using such components as were readily available to them, an account of which may be seen in [this BBC news report](#) (Jan 2021).

A fan pumps air through a high-grade HEPA filter worn on the belt and pipes it to the hood, providing a flow of purified, cooling air over the face. These devices are suitable for everyone regardless of gender, race or religion and, because they are not tight-fitting, wearers do not have to undergo a ‘face-fit test’. They also aid better communication with the patient compared with the FFP3 respirators or surgical masks as patients can see the HCW smile, lip-read, etc.

This novel type of powered respirator was eagerly accepted by staff and COVID infection rates greatly reduced. Following feedback from users, the style of the hood was refined as seen below.



Fig 2: The PeRSO Respirator Images: [Ric Gillams Photography](#)

6) 'Source Control' – IPC Considerations

Some IPC practitioners may be concerned that PAPRs do not provide 'source control', meaning that an infected HCW could present a risk to patients. This is an important point which needs to be properly addressed:

6.1 Prevention: Clearly the first consideration is to stop HCWs becoming a 'source' in the first place by preventing them from contracting the disease from their patients. This is particularly important when providing close-contact care where the patient's and HCW's breathing zones intermingle. General room ventilation does not create sufficient air velocity to disperse the aerosol plume before the HCW inhales the patient's expiration.

Therefore, where the disease may to any extent (i.e. 'wholly' or 'partially') be transmitted by the airborne route[†], then RPE {within the meaning of [COSHH Regulation 7\(9\)\(b\)](#)} must be provided. This does not include surgical masks of any type.

It is entirely logical that we protect HCWs in the best possible way. Apart from it being a moral and ethical imperative, it is also a basic requirement of UK legislation. In planning for any future pandemic it is essential that the provisions of health & safety legislation and the "duty of care" owed to healthcare workers must be the planners' foremost concern. Besides, from a pragmatic point of view, the country needs them at their posts to help us in our hour of need.

[†] "Airborne transmission" is taken to mean the process whereby aerosolised infectious respiratory particles are inhaled (as per the recent WHO definition "[Indoor airborne risk assessment in the context of SARS-CoV-2](#)"). It should be assumed that wherever "direct deposition" occurs (WHO's new term for "droplet transmission"), then aerosolised infectious respiratory particles will also be expelled, thereby mandating the use of RPE – the only difference being that the RPE must also have fluid resistant properties (a requirement which the visors of PAPRs satisfy).

6.2 Detection: Despite best endeavours to protect HCWs from occupational exposure to the disease, they may contract the disease in the community or elsewhere in the workplace. The risk of cross-infection to patients needs to be controlled as far as is reasonably practicable. This may be achieved by implementing a rigorous testing regime and scrutiny for symptoms, then removing them from front-line service. Elimination of the hazard represents the ultimate in "source control".

Nevertheless, despite all of the above, there will always be a need for "source control". For instance tests may not be available in the early stages of a pandemic, tests will usually return a proportion of "false negatives" etc. We therefore need to address the adequacy of PAPRs in comparison with surgical masks.

6.3 Efficacy as 'Source control': Whether or not one agrees with their "airborne/droplet dichotomy", WHO/Public Health/IPC have constantly reminded us throughout the pandemic, transmission of COVID-19 may occur through "droplets" and "aerosols". Considering these in turn:

- Droplets (i.e. "direct deposition"):
 - Surgical Masks:
Surgical masks compliant with BS EN 14683:2019 are designed to prevent transmission of droplets which may leave the wearer's nose or mouth and there is no reason to doubt that they do this effectively.
 - PAPRs:
A quick glance at the device in figure 2 above will soon reveal the impossibility of droplets escaping through the visor.
- Aerosols (i.e. "airborne infectious respiratory particles"):
 - Surgical Masks:
Expert researchers in bioaerosol transmission have opined that:
 - "Surgical masks do work as source control albeit very imperfectly. They only cut out about 50% of fine particle aerosols";
 - "Surgical masks serve more as a deflector of aerosol emissions rather than as a filter"
 - PAPRs:
Commercially available PAPRs do not filter aerosols from outbound breath.

So PAPRs and surgical masks both involve aerosol emission to a certain extent.

6.4 Precedent in IPC Guidance: It should be noted that at the outset of the pandemic, IPC guidance (issued 15 Jan 2020) allowed for the use of PAPRs (without expiration filters) as being a valid and perfectly acceptable form of RPE alongside FFP3s.

The 4-nations IPC guidance, from version 2 (April 2020) right through until it was withdrawn in 2022, recommended PAPRs as a valid and acceptable form of RPE. Thereafter the Scottish, English and Welsh National IPC Manuals have all continued to recommend PAPRs as a valid and acceptable form of RPE without any filtration of the expelled air.

6.5 Limitations: As described in [CAS alert Ref NatPSA/2021/009/NHSPS](#), powered respirators must not to be used when undertaking a sterile procedure or directly over the surgical field.

However, as discussed in section 8 below, the Southampton team have come up with a solution which overcomes these problems by filtering out exhaled aerosols.

7) RPE: Regulation and Enforcement

Discussion with Prof Paul Elkington MBE (pictured in fig 2 above, wearing a PeRSo) has revealed that the development team encountered numerous hurdles with the regulatory framework. They would ideally like to see an even more lightweight, user-friendly version of the PeRSo developed. However, attaining compliance and certification with the required standard (BS EN 12942) has proved problematical and discouraged interest in pursuing such a development. It is beyond the scope of this note to expand upon the technical issues involved. Suffice it to say that the safety requirements of the standard are primarily aimed at respirators used in manufacturing, chemical and other industry sectors where the working environment is quite different from healthcare. We see the need for a new BS EN standard for powered respirators that are to be used specifically in the healthcare sector. Alternatively perhaps, there could be a derogation from some aspects of the design and testing requirements within the existing standard.

8) Latest Developments

In July I visited Professor Paul Elkington at Southampton University Hospital accompanied by Mr Roger Kirkham of NHS Supply Chain, Clinical Engagement and Implementation Manager (PPE Management). We spoke with members of staff who had worn PeRSo respirators during the height of the pandemic. They gave moving accounts as to how, before the introduction of PeRSo, they had come to work scared, fearing for their lives and worried stiff that they might transmit the disease onwards to family members. However, they gave glowing reports as to how they felt after the introduction of PeRSo – relaxed, comfortable and confident in the reliable protection they now enjoyed.

Professor Elkington explained their latest initiative which is designed to overcome the issues of ‘source control’ described above. He demonstrated, a prototype that he and his team have developed which not only have inbound HEPA filtration, but also have outbound HEPA filtration on exhaled air.

These, through necessity, have to have a seal around the neck and, at first sight, seem even more “space age” than the ordinary version. However, this must surely be offset by the fact that urgent life-saving operations can safely continue during a pandemic without risk to or from the patient or other members of the operating team. We are only too aware of the awful consequences for patients needing such operations which could not be performed through the pandemic and the delays caused by the subsequent backlog. In other words these devices would be real life-savers.



Fig 3: PeRSo Respirator featuring HEPA filtration of exhaled air

Professor Elkington made the point that this is just a prototype and not yet in production. Before this can happen various hurdles of 'red tape' must be overcome in respect of modifications to the BS EN 12942 standard. Let's hope that these can be speedily overcome. Either that or a new standard developed, bespoke to powered respirators specifically for use in healthcare settings. There are several elements of BS EN 12942 required for industry which are unnecessary and inappropriate for use in medical settings.

The urgency of this work should not be underestimated with the ever-present threat of other pandemics, in particular from the Avian Flu H5N1 virus which is steadily evolving to acquire pandemic potential:

In 2021, a highly pathogenic influenza H5N1 clade 2.3.4.4b virus was detected in North America that is capable of infecting a diversity of avian species, marine mammals, and humans. In 2024, clade 2.3.4.4b virus spread widely in dairy cattle in the US, causing a few mild human cases, but retaining specificity for avian receptors. Historically, this virus has caused up to 30% fatality in humans, so Lin *et al.* performed a genetic and structural analysis of the mutations necessary to fully switch host receptor recognition. A single glutamine to leucine mutation at residue 226 of the virus hemagglutinin was sufficient to enact the change from avian to human specificity. In nature, the occurrence of this single mutation could be an indicator of human pandemic risk. —Caroline Ash

Source: **Science**, 5 Dec 2024, Vol 386, Issue 6726, pp. 1128-1134 [DOI: 10.1126/science.adt0180](https://doi.org/10.1126/science.adt0180)

With potential for over 10 times the lethality of SARS-CoV-2, our NHS services would likely be decimated within a few months (if not weeks) unless effective respiratory protection is provided to all healthcare workers in advance. But it is not just healthcare workers who need protection. Consider social care workers, "key workers" keeping food, medicines and other essential supplies moving, emergency services, local authorities, the armed forces who have played such a valuable role during the pandemic (and may be needed for other purposes) - no doubt many others.

Since the Government issued millions of gas masks before and during world war II, is this really such a big ask? Whilst welcoming the Government's move to purchase 5 million doses of a vaccine which it hopes would work against a novel variant of H5N1, vaccination must never be considered as the only protective measure. [HSE](#) confirm that vaccination falls below PPE in the 'hierarchy of control', so must not be solely relied upon where risk controls higher in the hierarchy (including PPE) can be implemented.

DFJ Osborn BSc CMIOSH SpDipEM
Chartered Safety and Health Practitioner ²

11 December 2024

² The author confirms that he has no commercial or conflict of interest in the matters to which this report relates.